APPENDIX A

MODELING
TECHNICAL SUPPORT DOCUMENT
FOR
DFW SIP

I. BACKGROUND

Under the 1990 Clean Air Act Amendments (Act), the Dallas - Fort Worth (DFW) area was classified as a Moderate nonattainment area. However, since the DFW area did not attain the NAAQS by its 1996 attainment date, it was reclassified to a Serious area in February 1998. The attainment date for a nonattainment area classified Serious is 1999. In November 1998, Texas submitted a SIP for the DFW area, however, EPA informed the State, that since the SIP lacked specified control measures for achieving attainment, the SIP was found incomplete. This finding initiated a sanctions clock. Texas then re-submitted a SIP in April 2000. The April 2000 SIP was found complete and thus stopped the sanctions clock.

Under EPA policy (July 1998) for nonattainment areas affected by transport, an area such as DFW, could be granted an attainment date extension, if it could be shown that the DFW area was affected by emissions from an up-wind nonattainment area with a later attainment date (e.g., Houston) to a degree that affects the downwind area's ability to achieve attainment. This TSD includes a demonstration that emissions from the Houston - Galveston (HG) Severe nonattainment area are affecting the DFW area to a degree that affects the area's ability to achieve attainment. Texas is requesting an attainment date extension to 2007, which is the attainment date for the HG Severe nonattainment area, the maximum that can be considered under the policy.

II. APPLICABLE EPA GUIDANCE

The Act requires ozone nonattainment areas designated serious and above, or multi-state moderate to demonstrate attainment of the ozone NAAQS through photochemical grid modeling or any other analytical method determined by the Administrator to be at least as effective. The EPA's <u>Guideline For Regulatory Application of The Urban Airshed Model</u> (July 1991) describes procedures which are intended to satisfy the Act's attainment demonstration requirements, foster technical credibility, and promote consistency among UAM regulatory applications. Associated with this Guideline, EPA published the <u>Guidance on Urban Airshed Model (UAM) Reporting Requirements for Attainment Demonstration</u> (March, 1994) to assist States in documenting the modeling procedures and results, so EPA can assess the adequacy of the modeling effort and the resulting control measures, and to facilitate public review of the proposed SIP revision.

In the October-December 1995 time frame, EPA revised the modeled test for demonstrating attainment of the ozone NAAQS. The EPA document entitled, <u>Guidance on Use Of Modeled Results to Demonstrate Attainment of the Ozone NAAQS</u> (June, 1996) was developed to better reflects experience gained in model applications since 1991.

In July 1998, EPA released its policy on extension of attainment dates for downwind transport areas. Texas has applied this policy to the situation of the HG area interfering with the ability of DFW to achieve attainment.

III. UAM MODELING ANALYSIS

A. Model Used

The TNRCC used the Comprehensive Air Quality Model with Extensions (CAMx) version 2.01 photochemical grid model to conduct both the SIP attainment demonstration modeling and the downwind transport modeling for the DFW ozone nonattainment area. Texas demonstrated that CAMx performed better than UAM version IV, the regulatory model, in the HG nonattainment area and petitioned EPA/6 to approve its use in the DFW nonattainment area. EPA/6 approved the use of CAMx for the DFW ozone nonattainment area. The TNRCC's modeling activities were performed as outlined in a series of the modeling protocols, according to EPA's "Guideline for Regulatory Application of the Urban Airshed Model" (*Guideline*). The final modeling protocol developed by the TNRCC was submitted in August 1999. Their protocol was reviewed and approved by the EPA/6.

B. Episode Selection

EPA's *Guideline* sets forth a recommended procedure for selecting ozone exceedance episodes appropriate for conducting a modeling demonstration. This procedure, in part, considers wind rose analyses based upon the four morning hours of 0700 to1000 standard time. These wind rose analyses are used to define the meteorological patterns for source-receptor relationships associated with high ozone events. TNRCC used this method for defining meteorological patterns. The number of ozone exceedance days for the period, 1990 - 1996, associated with each meteorological pattern was identified. The most prominent meteorological pattern was calm (i.e., wind speeds < 3mph) category with 70% of the ozone exceedance days. The second most prominent meteorological pattern was the southerly wind direction category with 25% of the ozone exceedance days.

Table 1. Candidate Episodes for Modeling

DATE	Morning Wind Direction	Maximum 1-Hr Ozone	Remarks
06/03/95	Calm	135 ppb	
06/13/95	Calm	135 ppb	
06/21/95	Calm	144 ppb	
06/22/95	Calm	135 ppb	
07/12/95	SSW	146 ppb	
07/13/95	Calm	159 ppb	
07/14/95	Calm	126 ppb	
07/28/95	SSW	126 ppb	
08/26/95	Calm	144 ppb	
07/03/96	WNW	144 ppb	enhanced aerometic monitors
09/06/96	Calm	139 ppb	enhanced aerometic monitors

To be more applicable to the most currently available emissions inventory (i.e., the

1996 Periodic) and to be more representative of recent meteorological conditions, TNRCC limited the candidate episodes to 1995 and 1996. A total of eleven ozone exceedance days (see Table 1) were identified as candidates for modeling. Ten of these ozone exceedance days were associated with calms or southerly winds. The eleventh day, July 3, 1996, occurred during a period of enhanced aerometic (i.e., meteorological and air quality) monitoring. The enhanced aerometric monitoring consisted, in part, of additional surface air quality monitoring (e.g., gas chromatographs), upper air meteorological monitoring (e.g., accoustic sodars), and some aircraft air quality sampling. In addition, July 3rd was preceded by two days with southerly winds and relatively high ozone (i.e., 112 - 114 ppb). TNRCC selected June 21 & 22, 1995, which form a multi-day episode, as two of the necessary three episode days to model from the calm meteorological regime. These two days also had 1-hour exceedances fairly close to the current ozone design value (i.e., 139 ppb), and had relatively high maximum 8-hour average ozone concentrations (i.e., 125 and 120 ppb, respectively). TNRCC did not select any other ozone exceedance days from 1995, including the ozone exceedance days during July 12 - 14, 1995. The maximum 1-hour ozone on the 13th & 14th of July were notably higher and lower, respectively, than the current design value, as well as both being associated with the calm meteorological regime, which is already represented by the selection of June 21- 22, 1995. However, the 12th was associated with southerly winds and had a relatively high maximum 8-hour average ozone concentration (i.e., 124 ppb). However, for the third episode day, TNRCC selected July 3, 1996. The rationale for this selection appears to be that it also represents southerly winds, since the two days prior exhibited southerly winds, and that it occurred during the period of enhanced aerometric monitoring.

To minimize the potential influence of initial conditions, TNRCC modeled several days prior to these exceedance days forming two modeling episodes: June 18-22, 1995 and June 30 - July 4, 1996.

C. CAMx Modeling Domain

TNRCC used a relatively large modeling domain (Figure 1.) to minimize the influence of uncertain boundary conditions and allow an assessment of regional transport. As seen in figure 1., the large grid (i.e., 32km x 32km) domain extends from a southwest Universal Transverse Mercator (UTM) coordinate (-300 UTM(E) by 2824 UTM(N), Zone 15) well inside Mexico to a northeast coordinate (1204 UTM(E) by 4136 UTM(N), Zone 15) just inside southeastern Kentucky. Within the large grid domain are two nested domains. The first nested domain, with 16km x 16km grids, covers most of East Texas with the southwest corner at coordinate -124 UTM(E) by 3192 UTM(N), Zone 15 and the northeast corner at coordinate 452 UTM(E) by 3832 UTM(N), Zone 15. The second nested domain, referred to as the core domain with 4km x 4km grids, encompasses the four county DFW nonattainment area, as well as a notable area to the east, west and south. The southwest corner of the core domain is at coordinate 16 UTM(E) by 3524 UTM(N), Zone 15 and the northeast corner is at coordinate 248UTM(E) by 3724 UTM(N), Zone 15. This domain encompasses all the major emission sources, and all surface and upper aerometric monitors pertinent to the DFW area for the two episodes selected. Actually for point sources within Texas, emissions levels of 10 tpy or greater were included.

The CAMx model uses fixed vertical layering (i.e, constant depths in time and space), unlike the UAM-IV which uses layers of variable thickness over time and space. The use of fix layering is an improvement of CAMx over UAM-IV, in part since the meteorological models use fixed vertical layering. Thus, the layering between the meteorological and photochemical model can be coordinated to minimize the amount of interpolation needed to map the vertical distribution of the meteorological parameters (e.g., wind speed, mixing coefficients) from the meteorological model to the photochemical model. TNRCC set up the vertical structure for CAMx with eight layers extending from the ground surface to 3030 meters (agl). The layer thickness increases monotonically from the lowest layer with a thickness of 20 meters to the eighth layer with a thickness of 910 meters. This vertical structure is used for all three horizontal grid zones. Typical summer afternoon mixing heights for the DFW area are 2000 meters (agl) (Holzworth, 1972). These are also the highest mixing heights for the entire modeling domain. Although, the top of the highest vertical layer (i.e., 3030 meters) appears to be well above the typical summer afternoon mixing height, the thickness of the highest layer (i.e., 910 meters) suggests that only one layer will be representing the meteorological parameters above the mixing height.

D. Meteorological Inputs

TNRCC developed the meteorological inputs to CAMx using the System Application International Mesoscale Model (SAIMM), which is a prognostic mesoscale meteorological model with four dimensional data assimulation (4DDA). This model is an adaptation and enhancement of the Colorado State University Mesoscale Model (CSUMM). EPA previously accepted TNRCC's use of the CSUMM for the phase I modeling of the HG and B/PA modeling domain along the Gulf Coast. EPA's acceptance was based upon the justification that a mesoscale prognostic model was needed to adequately replicate the land-sea breeze and inter-urban area transport features which appear to be typical of conditions associated with ozone exceedances along the Texas Gulf coast. Although the meteorological features of the DFW area are not as complex, EPA/6 has accepted TNRCC's use of SAIMM for the DFW attainment modeling. This acceptance is primarily based upon the capability of SAIMM to simulate dynamically balanced meteorological parameters providing better inputs to CAMx then could be developed using the Diagnostic Wind Model. This includes simulation of meteorological parameters in data sparse regions of the domain, and simulation of scalars (e.g., temperature gradients) in both time and space. SAIMM also simulates values for the vertical exchange coefficient (i.e., Kv), which is required by CAMx. The Kv's are used in CAMx to control the extent of the vertical mixing. Thus CAMx does not use mixing heights which are inputs to UAM-IV and used to limit the vertical mixing. Whereas the mixing height is a measurable meteorological parameter, the Kv is an unmeasurable surrogate controlling the mixing between layers. The vertical layer at which the magnitude of the Kv is insufficient to generate mixing is analogous to the mixing height. Thus the vertical distribution of the Kv's can be compared to mixing height measurements to determine whether the Kv's are generating the appropriate amount of vertical mixing.

The 4DDA capability of SAIMM allows for the "nudging" of certain simulated meteorological parameters (e.g., winds, temperature) with observed monitored data. Routine surface meteorological data from TNRCC's Continues Air Monitors (CAMs) network, local city-county programs, the FAA, NDBC, and National Weather Service (NWS), which includes twice daily NWS upper air soundings, were available for both episodes. In addition, the July 1996 episode occurred during an enhanced aerometric monitoring period, with additional upper air meteorological monitoring (e.g., acoustic sounders) which covered a portion of the core DFW area. Further, for the 1996 episode, additional aloft measurements of wind speed and direction were obtained from the MIT Lincoln Laboratory. This aloft wind data is collected at nine sites surrounding the DFW airport.

After reviewing the data, TNRCC determined that a portion of the available data would be excluded. This excluded data included some NWS sites in geographical regions where TNRCC CAMS or local city-county program sites were located. The TNRCC and local city-county sites typically collect surface surface meteorological data. TNRCC's rationale for excluding the NWS data was that the NWS data is a once per hour "instantaneous" observation, whereas the data from the CAMS and local city-county program sites are hourly "averaged" observations, and this difference constituted an inconsistency of input to the model. However, TNRCC did use the NWS data for "data sparse" areas.

The SAIMM was applied for the two episodes in the following manner. First, an application was made to a large (regional) domain, slightly larger than the CAMx large domain, with a southwest UTM-Zone 15 coordinate of -540 km (E) by 2648 km (N). This large SAIMM domain was horizontally configured at a grid size of 16 km by 16 km, extending 123 grids to the east and 107 grids to the north. Since the SAIMM determines parameter values at the grid intersections rather than grid centers, the large CAMx domain, with 32 km by 32 km grids will have grid centers that match with every other SAIMM grid intersection of the regional domain.

The second application of SAIMM was for a core domain with a southwest UTM-Zone 15 coordinate of 0 km (E) by 3364 km (N) with 4 km by 4 km grids, extending 62 grids to the east and 90 grids to the north. This puts the SAIMM core domain wholly within the first CAMx fine grid (i.e., 16 km X 16 km), while encompassing the CAMx second fine grid (i.e., 4 km X 4km). So the large SAIMM domain was used for the first CAMx fine grid, however, the 16 km X 16 km grids for these two domains exactly overlap one another. Therefore, the meteorological parameters had to be horizontally interpolated. Since the SAIMM core domain encompasses the CAMx second fine grid domain, it was used for determining the meteorological parameters. However, again, the 4 km X 4 km grids for these two domains exactly overlap one another, requiring the meteorological parameters to be horizontally interpolated. In addition, the northern boundaries of the 4 km X 4 km grid domains exactly overlap one another, which does not allow for any buffering from the assumed meteorological boundary conditions. Additionally, the SAIMM was implemented separately for the regional and core domains, which resulted in notable differences in the simulated meteorological parameters in those grid cells coincident between the two domains. These differences are due in part to the different grid cell size (i.e., 16km vs 4km), as well as the differences in the data used for the 4DDA application. TNRCC addresses the discrepancies in the winds by replacing the wind component values in the grids coincident between the two domains with a value derived using weighting factors applied to the regional and core wind values.

The vertical structure used in the SAIMM applications was the same for both episodes and both the regional and core domains. The vertical structure consisted of 19 layers extending from the ground surface to 8000 km (agl). The layer thicknesses (depths) are monotonically increasing with elevation. Information supplied in a previous transmittal from TNRCC, dated April 21, 1998, in response to comments on the modeling protocol, indicates that the consistency of the layering structure between the SAIMM and the CAMx extends through the center of CAMx layer 6 (i.e., SAIMM layer top 1050m). This suggests that interpolation is used for winds and thermodynamic parameters in mapping SAIMM results to CAMx layers seven and eight. A couple of rather odd features of the meteorological modeling is depicted in figure 2, a graphic showing the temporal distribution planetary boundary heights (PBLs) estimated from the model generated Kv's. The planetary boundary heights are equivalent to mixing heights and indicate the extent of vertical mixing. As figure 2 shows, the extent of the afternoon vertical mixing (i.e., about 1500 meters) is notably less than typical summer afternoon mixing height (i.e., about 2000+ meters) for the DFW area. In addition, the "collapse" of the PBL values in the late afternoon (about 1800 hours CST) seems earlier than would be expected, since late afternoon summer temperatures in the DFW area remain quite high and this would suggest more vertical mixing.

The simulated meteorological parameters from the 19 layer, 4km X 4km horizontally gridded SAIMM were "mapped" into the 8 vertical layers and variable nested grids of CAMx using a post-processor program called MM2CAMx. For the most part MM2CAMx interpolates the fields of meteorological parameters simulated by SAIMM into fields consistent with the CAMx vertical and horizontal grid structure. In performing the interpolation, two differing features of the SAIMM and CAMx are addressed. First, SAIMM simulates fields of meteorological parameters horizontally at grid "points" and CAMx at grid "centers." As mentioned above, the 16km X 16km SAIMM domain was off-set one-half grid cell from the CAMx domain to alleviate for this interpolation. The second feature applies to the vertical, SAIMM simulates fields of the horizontal wind components at the layer interfaces and the other parameters at the layer centers, whereas, all input meteorological parameters to CAMx are for the layer centers. The exception to this are the Kv's which apply at the CAMx vertical layer interfaces. To minimize the amount of interpolation in the vertical, the layering structure of SAIMM and CAMx are coordinated so the SAIMM layer interfaces, where the wind components and Kv's are simulated, correspond to CAMx layer centers.

E. Boundary and Initial Conditions

The lateral boundary (perimeter) of the regional modeling domain was divided into three segments: western, southern and northeastern. With reference to figure 1, the western boundary segment extended from Brownsville on the south, northwesterly along the Texas/Mexico border, then north to the Oklahoma-Kansas border, and finally easterly to the border with Missouri. The southern boundary represents the segment over water, extending east from Brownsville and south from the coast of the Florida pan-handle. The northeast segment composed the remainder of the boundary extending north from the coast of the Florida pan-handle on the east side and east from the Kansas/Missouri border on the north side. Table 2 summarizes the chemical species concentrations used for each of the boundary segments. With the exception of ozone concentrations for the northeast segment, the values in Table 2 were constant. In addition, the concentrations listed for the western boundary are the background default values. For six of the chemical species: methanol, ethanol, isoprene, CO, NO & NO2, non-EPA default values were used for either the southern or the northeastern boundaries or both. These non-EPA default values were the same as those used in the "Final Report: Future-Year Boundary Conditions for Urban Airshed Modeling for the State of Texas (Yocke, et al, 1996)." The ozone concentrations for the northeast segment were varied both spatially and temporally. TNRCC used ambient monitored ozone concentrations from 13 AIRS sites within close proximity to the northeast boundary segment to estimate the zone boundary concentrations. An inverse distance-squared weighted average ozone was determined from the 13 sites to each grid cell along the northeastern boundary segment for each hour of the two modeling episodes. For the daily period, 0700 - 1700 hours CST, it appears TNRCC used these weighted average ozone values for the boundary cells up through the 7^{th} vertical level (i.e., 2120 meters). The ozone concentration for the 8^{th} vertical level (i.e. the top layer) for this daily period was

Table 2. Boundary Conditions

	Boundary	Segment	Concentration (ppb)
Chemical Species	North east	West	South
Ozone	Spatially Interpolated	40	40
Carbon Monoxide (CO)	200	200	100
nitric oxide (NO)	0.1	0.1	0.01
nitrogen dioxide (NO2)	1.0	1.0	0.5
nitrogen oxides (NxOy)	0.0001	0.0001	0.0001
nitric acid (HNO3)	0.001	0.001	0.001
nitrous acid (HONO)	0.001	0.001	0.001
aldehydes (ALD2)	0.555	0.555	0.05
ethane (ETH)	0.51	0.51	0.15
formaldehyde (FORM)	2.1	2.1	0.05
olefins (OLE)	0.3	0.3	0.05
parafins (PAR)	14.94	14.94	7.6
toluene (TOL)	0.18	0.18	0.0786
xylene (XYL)	0.0975	0.0975	0.0688
isoprene (ISOP)	3.6	0.1	0.001
cresol (CRES)	0.001	0.001	0.001
methylglyoxal (MGLY)	0.001	0.001	0.001
open hydocarbons (OPEN)	0.001	0.001	0.001
peroxyacetylnitrate (PAN)	0.001	0.001	0.001
peroxynitric acid (PNA)	0.001	0.001	0.001
hydrogen peroxide (H2O2)	0.001	0.001	0.001
methanol (MEOH)	8.5	0.000001	0.000001
ethanol (ETOH)	1.1	0.00001	0.00001

the average of the weighted average ozone value (i.e., in the 7^{th} layer) and a value of 40 ppb, which is the EPA default for the modeling domain top. For the daily periods, 1800 - 2300 and 0000- 0600 hours CST, it appears TNRCC used these weighted average ozone values for the boundary cells up through the second layer, presumably to emulate the depth of the nocturnal inversion. For the next three layers (i.e., layers 3, 4 & 5), the ozone concentrations were estimated by multiplying the weighted average ozone value of the first two layers by 1.5, 2.0 & 2.5, respectively. For the remaining three layers (i.e., layers 6, 7 & 8), the ozone concentrations were presumably estimated by multiplying the weighted average ozone value of the first two layers by 2.0, 1.5 & 1.0, respectively.

The EPA default background values (i.e., the values for the western boundary in Table 2) were used for the top of the modeling domain boundary.

The initial conditions were developed from surface monitored O3, NO, NO2, & CO concentrations. For those surface layer grid cells which had no near-by monitors, default values of 20ppb O3, 0.1ppb NO, 1.0ppb NO2 and 200ppb CO were used. TNRCC's rationale for these default values was that the simulation begins at midnight and that these are typical midnight values as reported in the EPA AIRS database. EPA background default concentrations were used for the other chemical constituents. To minimize the influence of the initial conditions, TNRCC did employ two start-up days for each of the episodes instead of the EPA recommendation of at least one.

F. Emissions Inventory

TNRCC developed two major types of modeling emission inventories, one type representing the actual emissions that occurred during the specific episodes, and another type representing the projected emissions expected to occur at the attainment date (i.e., 2007). The episode specific modeling emissions, termed the "base case", were used to evaluate the model's (i.e., CAMx) reliability in replicating the ozone exceedances that occurred during the episode. The 2007 projected modeling emissions, termed the "future case" were used to estimate the overall level of reductions in VOC and NOx needed to achieve attainment.

EPA's recommended emissions processing system for developing base case and future case modeling emissions inputs to photochemical models is called EPS2.0. EPS2.0 is a composite of emission processing components specific to the various emission source categories, i.e., point, area, on-road and off-road mobile, and biogenic sources. The input to EPS2.0 is a typical ozone season emissions inventory. For base case modeling emissions, these ozone season emissions are adjusted for pertinent conditions related to the episode days to be modeled, producing day-specific emissions as the output from EPS2.0. For future case modeling emissions, a base year (e.g., 1996) ozone season emissions inventory is adjusted for growth and controls producing the attainment date projected emissions as the output from EPS2.0. For a number of the emission source categories (e.g., on-road mobile) TNRCC used state-of-the-science methods which produced better estimates of the day-specific emissions than EPS2.0.

1. The DFW Base Case Modeling Emissions Inventory

TNRCC used an enhanced proprietary version of EPS2.0, developed by SAI and sold as Fast-EPS, in developing the point, area and off-road mobile source emissions. In addition, as indicated above state-of-the-science approaches were used for the on-road mobile emissions within the core domain and for the biogenic emissions in both the regional and core domains. On-road mobile source emissions for the regional domain were developed differently for different geographical segments. For that portion of the regional domain that constituted the COAST domain used for the HG SIP, on-road mobile source emissions were derived from those used in the HG SIP modeling. For that portion of the regional domain that covered the remaining 95 counties in East Texas, recently developed NET on-road emissions data (i.e., by TNRCC) were used with Fast-EPS. The on-road mobile source emissions for the remainder of the regional domain were developed from the EPA NET data input to Fast-EPS.

Subsequent to the development of the initial base case modeling emissions inventory, a number of changes were made due to changes in the modeling domain structure, as well as, changes in the emissions data itself. The changes to the horizontal structure of the modeling domain involved a reduction in the geographical size of the core domain to approximately just the 12 counties of and around the 4-county DFW nonattainment area, and the creation, out of the Regional domain, of a sub-domain encompassing the new core domain, as well as the remaining 95 counties in East Texas. Thus the revised modeling domain, as shown in Figure 3, was composed of three domains in a serial nested fashion. There were a series of changes to the actual emissions data that resulted in a series of base case modeling emissions inventories, each constituting a refinement or correction to an error.

a. Point Sources

The point source modeling emissions were developed by considering two sub-categories and four geographical regions. The sub-categories were electrical generating units (EGU's) and all other point source categories, i.e., non-EGU's (NEGU's). The four geographical regions were: the State of Texas within the modeling domain, the off-shore region (i.e., Gulf of Mexico) within the modeling domain, the State of Louisiana, and all other states within the regional modeling domain. Thus, seven point source modeling emissions files were initially developed using Fast-EPS and then merged together for input to CAMx (note that there are no Off-shore EGU's).

Several data sources were accessed to gather the inputs for Fast-EPS. Emission data for most EGU's is available from the EPA Acid Rain Program Data Base (ARPDB) and/or the data base compiled for the EPA NOx SIP Call. In addition, hourly emissions for some EGU's were available from Texas Utilities and Houston Light & Power (Reliant Energy). These three sources of data provided the bulk of the emissions data for the three on-shore geographical regions. TNRCC maintains a Point Source Data Base (PSDB) from which the emissions data for NEGU's within the State of Texas was gathered. The initial emissions data within the PSDB that was used corresponded to the 1996 Periodic Emissions Inventory (PEI), compiled in accordance with the 1990 FCAAA. The NEGU data for the State of Louisiana was gathered from their 1996 PEI. The Louisiana Department of Environmental Quality (LADEQ) indicated that the 1996 PEI was superior to the 1996 National Emissions Trends (NET) data base. For the remaining states within the modeling domain, the NEGU emissions data were taken from the data base compiled for the EPA NOx SIP Call. TNRCC used the model-ready, 1993 episode specific off-shore point source file. This file was originally developed by SAI from a 1992 MMS emissions inventory for the 1993 COAST/GMAQS modeling project.

Most of the state-of-the-science photochemical air dispersion models (e.g., CAMx) include an option to model some point sources with a plum-in-grid (PIG) feature. The PIG feature results in a periodic release of the point source emissions potentially over several grid cells, rather than immediately into a single grid cell. TNRCC selected 187 point sources for PIG treatment. The majority of these sources were EGU's located in and around the 4-county DFW nonattainment area. Where selected PIG sources were in close proximity, they were combined into one source. In this way, TNRCC reduced the number of PIG sources to 99, which somewhat lessened the computational time required by the model to process these sources.

b. Area and Off-Road mobile Sources

TNRCC developed the modeling emissions for the area and off-road mobile sources as one entity, since they are treated very similarly in Fast-EPS. In addition, some what similar to the point sources, three modeling emission files were developed for each of three geographical regions and then merged. The three geographical regions were: the original 4km X 4km, "core" modeling sub-domain, the off-shore region (i.e., Gulf of Mexico) within the modeling domain, and the remainder of Texas as well as all other states within the regional modeling domain.

The original 4km X 4km, "core" modeling sub-domain covered wholly or in part 56 counties; of this, 37 counties comprise an area referred to as the D-FW Study Area Grid. TNRCC contracted with the North Central Texas Council Of Governments (NCTCOG) to gather and develop emissions data for specific area and off-road emission source categories: refueling at gasoline stations, aircraft, railroad, recreational boating, construction equipment, and residential lawn mowing within the 37-county D-FW Study Area Grid. In addition, the NCTCOG investigated the previously un-inventoried non-driven vehicles, which primarily include unregistered vehicles on car lots. NCTCOG conducted special studies to gather new emissions related data upon which they developed daily emissions for each of the above mentioned categories for the 37-county D-FW Study Area Grid. The spatial resolution of the daily emissions was county-wide, and also by zip code area. The exceptions to this were for recreational boating, which was by individual lake, and aircraft support equipment, which was by individual airport. TNRCC developed special surrogates based upon zip code area and based upon individual lakes, for the respective source categories, to spatially allocate the emissions by grid cell.

Daily emissions for the area and off-road source categories not included in the NCTCOG contract were developed by TNRCC staff from the 1996 PEI. The spatial resolution of these emissions was county-wide only. And they were spatially allocated to the various grid cells within the 37-county D-FW Study Area Grid using the standard Fast-EPS surrogates (e.g., population density). For those area and off-road source categories that are assigned a geographical surrogate, NCTCOG developed updates to the standard United States Geological Survey (USGS) Land Use Land Cover (LULC) data for the 37-county D-FW Study Area Grid.

TNRCC estimated the daily emissions in the remainder of the 56 counties (i.e., 19 counties) by multiplying the Collin county daily emissions of each area and off-road source category by the ratio of the specific county's population to that of Collin County. Apparently, TNRCC considered the Collin county emissions to population density to be similar to the other 19 counties.

Similar to the off-shore point sources, TNRCC used the model-ready, 1993 episode specific off-shore area and off-road source emissions file. This file was originally developed by SAI from a 1992 MMS emissions inventory for the 1993 COAST/GMAQS modeling project.

The area and off-road emissions for the remainder of the modeling domain were developed using the data from the 1996 NET. The NET data is for an ozone season day at a county-wide spatial resolution. This emissions data was spatially allocated to the 16km X 16 KM original regional domain using surrogates developed by ENVIRON, under contract to TNRCC. The geographical surrogates, developed by ENVIRON were based upon the standard USGS LULC data.

Different chemical speciation profiles of the VOC emissions for a majority of the various area and off-road source categories were used instead of the default profiles provided in EPS2.0. These profiles were developed by ENVIRON & DRI and SAI under contracts to TNRCC. The profiles developed by ENVIRON & DRI focused primarily on VOC's from gasoline and diesel fuel combustion and evaporization. The chemical speciation profiles from SAI had been developed for the COAST study. The profiles developed by SAI were used for the various area and off-road source categories, for which profiles were not developed by ENVIRON/DRI. These chemical speciation profiles applied to over 80% of the area and off-road VOC emissions. The EPS2.0 default profiles were used for the remaining source categories.

In general, EPA/6 feels the procedures TNRCC used to develop the area and off-road source emissions are acceptable

c. On-Road Mobile Sources

The on-road mobile source emissions were developed for five separate geographical regions:

1. The five county region covered by the D-FWRTM,
2. The remaining 32 counties of the 37-county D-FW Study Area Grid,
3. The eleven counties comprising the HG and BPA nonattainment areas,
4. The remaining Texas counties within the modeling domain, and
5. All the other states or portions of states within the regional modeling domain.

Modeling emission files were developed for each of these regions and then merged to get the final modeling files.

The 5-county D-FWRTM region consists of the four DFW nonattainment counties as well as Rockwall county (see Fig. 1). The on-road emissions for this region were developed by NCTCOG using a travel demand model (TDM) and the MOBILE5a emission factors model. The TDM estimates VMT and speeds on roadway links comprising the roadway network covering the D-FWRTM region. These results are used with MOBILE5a results (e.g., grams/VMT for LDGV at 35mph) to generate exhaust emissions on the various roadway links. The diurnal and hot-soak emission, as well as the exhaust emissions arising from traffic on local streets were developed somewhat differently. While the emission factors were still developed using MOBILE5a, NCTCOG allocated the emissions to traffic area zones (TAZ) rather than roadway links. This provided the opportunity to spatially and temporally allocate these emission types (e.g., hot-soaks) to the geographical location where they predominately occur. From the data supplied by NCTCOG, TNRCC initially developed two modeling emission files, one based on the TDM and one based on the TAZ's, using EPS2.0. These two files were subsequently merged.

The data supplied by the NCTCOG was divided into 15 different time periods per day for both episodes. There was one time period for each of the hours from 0500 to 1900 hours CST (i.e., 14-hourly periods), plus one time period for the overnight hours (i.e., 2000-0400 CST). TNRCC applied a uniform temporal distribution to the emissions in the overnight time period to disaggregate it into 10 hourly time periods with equal emissions.

The chemical speciation profiles developed by ENVIRON & DRI under contract to TNRCC were used instead of the default profiles in EPS2.0. Specifically, ENVIRON & DRI developed profiles for gasoline and diesel exhaust, gasoline vapors and liquid gasoline.

TNRCC also adjusted the emissions to account for differences between Highway Performance Measurement System (HPMS) Vehicle Miles Traveled (VMT) estimates and those generated by the TDM. TNRCC multiplied both the link-based and zone-based CO, NOx & VOC emissions by 1.056 to adjust for HPMS.

The on-road emissions for the remaining 32 counties of the 37-county D-FW Study Area Grid were also developed by NCTCOG. Using county-wide HPMS VMT estimates for each of eight HPMS roadway types (i.e., functional classes) and the MOBILE5a emissions factor model, NCTCOG estimated the county-level emissions. TNRCC developed roadway links using the roadway data files from the 1990 U.S. Census Bureau. Since these data files have fewer roadway type designations, emissions from the seven major HPMS functional classes were consolidated into two of the Census Bureau file designations: Interstate Highway, and State or U.S. Highway. TNRCC spatially allocated the exhaust portions of these two roadway types by the length of the link. For the diurnal and hot-soak emission, as well as the exhaust emissions on the minor HPMS functional class, the spatial allocation was by population. For the diurnal temporal allocation, TNRCC used week-day and week-end diurnal profile previously developed for BPA, which is also characterized by relatively small urban areas.

TNRCC chemically speciated the VOC's for this geographic region using the default EPS2.0 profiles, rather than the profiles developed by ENVIRON/DRI or SAI. Similar to the emissions modeling file development for the 5-county D-FWRTM region, TNRCC initially developed two files which were later merged.

Gridded hourly on-road emissions for the eleven HG and BPA nonattainment counties were previously developed by Texas transportation Institute (TTI) for the COAST project. This included gridded hourly on-road emissions forecasted to 1996. TNRCC used the 1996 forecasted emissions for August 19th, which was the day in 1993 for which the highest ozone concentration was recorded in Houston, for all DFW episode days. Since the 1996 forecasted emissions were already spatially and temporally allocated, these procedures were not needed. However, TNRCC did re-speciate these emissions using the on-road chemical speciation profiles developed by ENVIRON/DRI.

For the region comprising the remaining Texas counties, TNRCC used the on-road emissions developed by TTI for inclusion in the 1996 NET. TTI used county-wide HPMS VMT estimates for each of the HPMS functional classes and the MOBILE5a emissions factor model to estimate the county-level ozone season daily emissions. These county-level emissions were spatially allocated, again using the consolidation of the HPMS functional classes into the two TIGER line file designations, by the length of the links. However, for this geographic region, the non-exhaust VOC components (e.g., hot-soak) for the major HPMS functional classes were also allocated to the links. For both non-exhaust and exhaust emissions on the minor HPMS functional class, the spatial allocation was by population. Since a portion of this region was within the 4km X 4km modeling sub-grid and the remainder was in the 16km X 16km regional modeling grid, TNRCC developed two modeling emission files. These files were not merged together as they represent different spatial resolutions.

The temporal distribution of the ozone season daily emissions was done in two steps. First the ozone season daily emissions were adjusted for day-of-week. TNRCC used day-of-week adjustment factors, previously developed for the COAST project, based upon day-of-week variations in VMT. These factors convert ozone season daily emissions to week-day (i.e., Monday through Thursday), Friday, Saturday or Sunday daily emissions. As an example, for July 3rd of the DFW 1996 episode which was a Wednesday, the ozone season daily emissions were adjusted to represent a Friday, and for July 4th to represent a Sunday. The same day-of-week adjustment factors were used for all counties, except those counties with coastal shorelines (e.g., Matagorda county). Based upon the COAST project, in coastal counties week-end (i.e., Saturday & Sunday)VMT was typically larger than week-day, which is opposite that for non-coastal counties. The second step was to distribute the day-of-week daily emissions diurnally. Again, TNRCC used the diurnal profiles previously developed as a part of the COAST project. There were separate profiles for non-coastal and coastal counties, as well as for day-of-week.

The chemical speciation profiles used by TNRCC for this geographical region were based upon an analysis of the Mt. Baker Tunnel Study conducted by Desert Research Institute (DRI) (i.e., Dr. Fujita). Although the Mt. Baker Tunnel Study reportedly reflects usage of non-reformulated gasolines, these speciation profiles may be applicable to this geographical region.

For the geographical region comprising the other states, which are all within the regional 16km X 16km modeling grid, TNRCC used ozone season daily, county-wide emissions obtained from the 1996 NET. Both the non-exhaust and exhaust emissions were spatially allocated using the population surrogate. Thus no roadway links were used for spatially allocating any of the on-road emissions in the other states. For example, emissions were not allocated to Interstate Highway 35 in Oklahoma, but rather most of the emissions would have been allocated to Oklahoma City and Tulsa because of the higher population density.

The ozone season daily emissions were not adjusted for day-of-week, but the same diurnal profiles used for the remaining Texas counties region (i.e., those counties not part of the 37-county DFW Study area or the 11-county HG & BPA nonattainment areas) were used for the other states. This includes the different profiles for non-coastal versus coastal counties. TNRCC used the EPS2.0 default chemical speciation profiles for the VOC's from on-road mobile sources in this region.

In general, EPA/6 feels the procedures TNRCC used to develop the on-road source emissions are acceptable.

d. Biogenic Sources

The biogenic emissions were developed for two separate geographical regions:
1. The 37-county D-FW Study Area, and
2. The regional modeling domain.

The 37-county D-FW Study Area is slightly different than the 37-county D-FW Study Area Grid for the on-road sources. The 37-county D-FW Study Area for the biogenics corresponds to the original core modeling domain.

For the 37-county D-FW Study Area, TNRCC estimated emissions from biogenic sources using parts of two biogenic emissions models. The Emissions Modeling System 95 (EMS95) module called BIOME was used primarily because of the ability to more easily incorporate locally-developed biomass, and EPA's Biogenic Emissions Inventory System 2.0 (BEIS-2) was used primarily based upon expert advice that BEIS-2 possessed the better emission factors. To use the BEIS-2 emission factors with BIOME, TNRCC had to convert the form of the BEIS-2 emission factors to that used by BIOME. The BEIS-2 emission factors are in the form of a flux term (i.e., $ug/m^2/hr$) and BIOME uses emission factors in the form of a ratio of the emission as carbon (C) to the leaf biomass (LBM) (i.e., ug-C/g-LBM/hr). This requires a knowledge of the geographical LBM density (i.e., g-LBM/m^2). TNRCC indicated that they used LBM densities published in Geron, et al.1994. "An Improved Model for Estimating Emissions of Volatile Organic Compounds From Forests in the Eastern United States" and the 1996 EIIP. For some vegetative species BEIS-2 emission factors were not available, so TNRCC used published emission factors from Wilkinson, et al.1995. "An Inter-comparison of Biogenic Emission Estimates From BEIS-2 and BIOME: Reconciling the Differences" and Benjamin and Winer.1998. "Estimating the Ozone Forming Potential of Urban Trees and Shrubs."

As indicated, TNRCC used BIOME to utilize the locally developed vegetative and land use data. For the 37-county D-FW Study Area, TNRCC obtained this data from the NCTCOG (un-published) and the Texas Parks and Wildlife Department (MacMahan, et al.1984. "The Vegetation Types of Texas"). In addition, ENVIRON under contract to TNRCC (Yarwood, et al.1997. "Final Report: Leaf Biomass Density Data for North-Central Texas"), conducted a field survey of representative locations throughout the 37-county D-FW Study Area to identify vegetative specie types within the various land use categories and estimate their LBM density. Agricultural crops were not included in the ENVIRON field survey. TNRCC estimated the crop specific vegetative species and the LBM densities from 1995 county-wide crop harvest data provided by the U.S. Department of Agriculture, National Agriculture Statistics Service.

For the regional modeling domain, TNRCC used BEIS-2 primarily since the only readily available biogenics land use data base was the one incorporated in BEIS-2.

EPA/6 feels the procedures TNRCC used to develop the biogenic emissions are acceptable. The initial biogenic emissions inventory was changed considerably, in part, due to the unrealistically high isoprene concentrations generated in CAMx.

Table 3 summarizes the modeling emissions TNRCC developed for the various source categories for the 4-county DFW nonattainment area. This modeling emissions inventory was termed the base4d emissions.

Table 3. Summary of Base4d Modeling Emissions
4-County DFW Nonattainment Area

Source	**June 1995**	**Episode**	**July 1996**	**Episode**
Categories	**VOC**	**NOx**	**VOC**	**NOx**
Point Sources	29 tpd	81 tpd	29 tpd	99 tpd
Area/Off-road	252 tpd	127 tpd	294 tpd	156 tpd
On-road	206 tpd	308 tpd	235 tpd	314 tpd
Biogenic	327 tpd	10 tpd	453 tpd	13 tpd
Totals	814 tpd	526 tpd	1010 tpd	583 tpd

e. Base Case Emissions Inventory Evaluation

For many of the technical procedures used to develop modeling emission inventories, TNRCC used alternate applications (e.g., state-of-the-science) that should provide better estimates of the episode specific emissions from the various sources. EPA is supportive of the alternative techniques and additional efforts TNRCC has employed to produce better modeling emission estimates. In addition to the use of improved emissions modeling techniques, TNRCC conducted a special aerometric monitoring study of the DFW nonattainment area during the summer of 1996. This study included the monitoring of ambient VOC's from the deployment of two gas chromatographs (GC's), which have continued to operate as part of the PAMS program for the DFW nonattainment area. One of the stated goals of the PAMS program, which includes the monitoring of ozone precursors, is to provide data to evaluate photochemical models and their inputs. The availability of precursor data provides the opportunity to further evaluate the emissions inventory by making comparisons, where appropriate, between the emissions estimates and monitored data of the precursors. This is a compelling opportunity, since the precursors are the parameters that are reduced to test control strategies and since TNRCC used alternative applications to estimate the emissions from various sources (e.g., biogenics). Thus, having some indication of how well the emissions estimates and monitored ozone precursors compare, provides an additional indication of the reliability that can be placed on the alternative applications as well as the modeled control strategy results.

Although there is no requirement that this type of an emissions inventory evaluation needs to be part of the SIP attainment demonstration, TNRCC committed, in the modeling protocol for the DFW attainment demonstration, to use the data from the 1996 special monitoring study to evaluate the base case emissions inventory. EPA/6 was receptive to the emissions inventory evaluation since it would help validate TNRCC's use of alternative techniques for estimating emissions. As a result, TNRCC did use some of the more obvious inconsistencies between the CAMx modeling results and the ambient measurements to adjust the base case modeling emissions. For example, comparisons of monitored and modeled isoprene concentrations, a "finger-print" biogenic VOC, using the base4d emissions indicated that biogenic emissions were likely over-estimated. Based upon this inconsistency in the concentrations of isoprene and the availability of a new biogenic emissions modeling system called GLOBEIS, available from ENVIRON, TNRCC developed a new emissions modeling inventory, termed Base5.

The new emissions modeling inventory, Base5, also included changes to point, aircraft and on-road mobile emissions. Although these changes did not the result from the comparison of modeled and monitored precursor concentrations. The changes to the point source emissions involved adding a small number of sources which had inadvertently been left out of the Base4d emissions modeling inventory. The changes to the aircraft emissions involved treating emissions occurring during approaches and climb-outs as a series of pseudo elevated point sources. This had the effect of redistributing emissions to the upper layers of the model. The changes to the on-road mobile emissions involved accounting for emissions associated with traffic incidents, such as accidents that notably reduce speeds and therefore increase emissions. These changes are examples of the TNRCC's use of alternative emission estimating techniques.

TNRCC subsequently developed another new emissions modeling inventory, termed Base6. Base6 was developed as a result of changes made to the construction equipment emissions. Under contract to TNRCC, Eastern Research Group (ERG) conducted a study of construction equipment emissions in the Houston/Galveston nonattainment area. ERG also developed a scaling procedure, primarily based upon equipment population, to estimate revised construction equipment emissions in the DFW nonattainment area.

Finally, TNRCC developed emissions modeling inventory Base6a. Base6a included changes to emissions from airport ground-support equipment at Alliance, Meachem, Love, and DFW International Airports developed by the Airline Transport Association (ATA), and another revision to the construction equipment emissions addressed in Base6. This additional revision to the construction equipment involved using the survey based operations data instead of the EPA defaults in the Non-Road model. Similar to the emission estimate revisions that created the base5 modeling emissions inventory, the revisions creating base6 and base6a are examples of the TNRCC's use of alternative emission estimating techniques.

Table 4. presents a comparison of base6a and base4d modeling emissions for the 4-County DFW nonattainment area. As the table shows, the largest difference is in the biogenic sources, however, there was a notable change to the area/off-road NOx emissions. The decrease in the area/off-road NOx emissions from the base4d to the base6a emissions is primarily a result of the revision to the construction equipment emissions.

Table 4. Comparison of Base6a & Base4d Modeling Emissions
4-County DFW Nonattainment Area

Source	Base4d	7/96-Episode	Base6a	7/96-Episode
Categories	VOC	NOx	VOC	NOx
Point Sources	29 tpd	99 tpd	29 tpd	99 tpd
Area/Off-road	294tpd	156 tpd	293 tpd	123 tpd
On-road	235 tpd	314 tpd	235 tpd	322 tpd
Biogenic	453 tpd	13 tpd	258 tpd	27 tpd
Totals	1010 tpd	583 tpd	815 tpd	571 tpd

2. The DFW Projected 2007 Emissions Inventory

In developing a projected 2007 modeling emissions inventory, TNRCC first developed a future, 2007 base, which consisted of adjusting the episodic (i.e., June '95 and July '96) modeling emissions for growth and regulations (i.e., federal and state) already contemplated for implementation prior to 2007. The procedures used to develop the adjustments to account for the growth and impending regulations were specific to the various emission source categories. The biogenic emissions were assumed to remain the same.

In concert with the progression of the episodic modeling emission inventories from Base4d to Base6a, there were a series of future 2007 base modeling emission inventories. Aside from reflecting the various episodic emission changes (e.g., changes to aircraft emissions), there were also some changes in the procedures for developing the adjustments for growth and the impending regulations. The future 2007 base modeling emission inventory derived from Base4d was termed 2007b, and the future 2007 base modeling emission inventory derived from Base6a was termed 2007k. From the series of future 2007 base modeling emission inventories, TNRCC then created control strategy modeling emission inventories. These control strategy modeling emission inventories were created by further adjusting the future 2007 base modeling emission inventories to account for additional control measures (e.g., 9-county I/M) being considered. These control measures were in addition to the impending regulations already accounted for in the 2007 base modeling emission inventories. Thus a considerable amount of modeling was conducted before the final control strategy modeling emission inventory (i.e., D_{ATT}) was created.

a. Future 2007 Point Source Emissions

For development of the initial 2007 base point source emissions (e.g., 2007b), TNRCC divided the point sources into two groups: electrical generating facilities (EGFs) and non-electrical generating facilities (NEGFs). This was done primarily to accommodate the impending regulations from two laws the 1999 Texas Legislature passed to reduce emissions. One of the laws, Senate Bill 7 (SB-7), mandated that Grandfathered (i.e., un-permitted) EGFs in Central and Eastern Texas (i.e., attainment areas) reduce their NOx emissions to 50% of their 1997 levels. The other law, SB-766, encourages grandfathered NEGFs, through economic incentives, to voluntarily acquire state permits, which would require these sources to meet current Reasonable Available Control Technology (RACT). It was estimated by TNRCC, that if 100% of the grandfathered NEGFs acquired state permits, this would reduce their combined emissions by about 30%. Along with these legislative mandates, TNRCC adopted a rule to reduce NOx emissions from permitted EGFs state-wide, considered another impending regulation. TNRCC's rule is intended to reduce permitted EGFs emissions in Central and Eastern Texas by 50% of their1997 levels, and 30% of their1997 levels elsewhere.

Since the provisions of SB-7 and the TNRCC's rule are based upon 1997 NOx emission levels, adjustments for growth and impending regulations of the EGF emissions were not developed to apply to the Base4d, which was based upon 1995 and 1996 emission levels. Instead, TNRCC developed a 1997 EGF emissions inventory from CEM data available in the Acid Rain Program Data Base (ARPDB). The ARPDB CEM data for the three months of June, July & August 1997 were averaged to arrive at a typical ozone season daily emission, and the hourly CEM data were used to develop a diurnal emissions profile. No growth was assumed for these sources, so the adjustment was only for impending regulations. To generate the 2007 base for EGFs, TNRCC reduced all EGFs typical ozone season daily emissions (i.e., grandfathered and permitted) in Eastern and Central Texas by 50% and by 30% in the remainder of the state, excluding the DFW and HG nonattainment areas as they will have more stringent controls.

For the NEGFs, the adjustments for growth and impending regulations were applied to the Base4d modeling emissions inventory. To project growth in the NEGF emissions, TNRCC abandoned the REMI/EGAS technique they had proposed. This was due to a concern that the REMI/EGAS technique, which is primarily based upon economic growth would over-estimate emission growth, since newer NEGFs, with new technology, are expected to be less polluting. In addition, TNRCC concluded from their own survey that point source emissions have been decreasing across the state. Using this survey, TNRCC developed growth factors for four Texas regions within the modeling domain:

1. the 4-county DFW nonattainment area,
2. the 8-county HG nonattainment area,
3. the 3-county BPA nonattainment area, and
4. the remaining counties in Texas within the modeling domain.

The survey was only detailed enough, to develop growth factors for these four regions as a whole. That is, all NEGF point sources within a given region were assigned the same growth factor with out regard to their specific source category code. For each of these four areas the growth factor was less than or equal to 1.000, indicating a decline or no growth in emissions between 1996 and 2007. The adjustment for impending regulations to the NEGF emissions were based only upon the provisions of SB-766. So, NEGF sources which were identified as grandfathered were reduced by 30%, permitted NEGFs were not reduced. For sources whose status could not be determined, a weighted average of 13% reduction in emissions was used. As with the EGFs, these control factors were not applied to NEGFs in the DFW and HG nonattainment areas, as they will have more stringent controls.

To account for new sources of EGF & NEGF, TNRCC compiled the emissions for new air permits the state had approved or that were under review as of October 1999. Emissions from these sources (i.e., primarily EFGs and cement kilns) within 100 miles of the DFW nonattainment area were included in the 2007 base point source emissions. A further adjustment was made to the point sources in the BPA nonattainment area to account for the substantial amount of banked emissions. Therefore the growth factor for the EGF & NEGF in the BPA nonattainment area was adjusted to account for the re-occurrence of banked emissions. TNRCC has an emission reduction credit (ERC) banking program. Banked emissions are not included in emission inventories, but they are available for use by facilities that may need emission credits. Therefore banked emissions should be accounted for in the future emissions inventory. However, no banked emissions, as of 1997, were included in the 2007 base modeling emissions inventory for either HG or DFW.

For point source emissions in those states included in the NOx SIP Call, TNRCC used an overall NOx emissions adjustment factor of 0.41 (i.e., a 59% reduction). For those states not included in the NOx SIP Call, TNRCC used an overall point source NOx emissions adjustment factor of 0.70 (i.e., 30% reduction). Presumably, TNRCC feels that non NOX SIP Call states will also be forced to reduce their NOx emissions by 2007. As for off shore point sources, TNRCC assumed no impending controls.

b. Future 2007 Area and Off-Road Mobile Sources

Similar to projecting growth in the point source emissions, TNRCC abandoned the REMI/EGAS technique they had proposed. This was due to a concern that the REMI/EGAS technique, generally predicted growth which appeared too small given the recent growth in the whole region. TNRCC used the estimated population growth in the modeling domain as the surrogate for the growth in the area and off-road emissions. For the DFW 4-county nonattainment area, TNRCC used growth projections obtained from the Texas Comptoller and for the remainder of Texas, growth projections obtained from the Texas A & M University. For the other states within the modeling domain, TNRCC used the 1990 Series A population growth estimates from the U.S. Census Bureau.

For the 2007 area and off-road base modeling emissions inventory (e.g., 2007b), TNRCC only included those controls associated with impending federal regulations (e.g., off-road diesel). The control adjustments for most of the pertinent off-road sources were determined using the EPA NONROAD model, by setting the 1995/96 to 2007 growth to zero and ratioing the resulting emissions with the Base4d episodic modeling emissions. In addition, TNRCC included stage I vapor recovery within Central and Eastern Texas as part of the 2007 area and off-road base modeling emissions inventory.

TNRCC combined the county population growth estimates with the controls for the applicable area and off-road source categories to generate the adjustment factors to apply to the Base4d modeling emissions to generate the 2007b future base modeling emissions.

c. Future 2007 On-Road Mobile Sources

TNRCC used the same methodology to develop the 2007 on-road mobile source emissions as was used for the 1995/96 episodic modeling emissions. Different techniques were used for different portions of the modeling domain.

For the 5-county DFWRTM area, the future 2007 on-road emissions were developed by NCTCOG using their travel demand model and MOBILE5a. The modeling inputs included the projected 2007 roadway network, demographics data, NLEV and

HDDV standards, Phase II RFG, Texas Motorist Choice I/M (i.e., Dallas & Tarrant counties only) and Tier II/Low Sulfur rule. In addition, for the 2007 on-road emissions, TNRCC assumed a vehicle age distribution with a lower average age. TNRCC justifies this change indicating that recent Texas Department Of Transportation (TxDOT) shows the current average vehicle age to be lower than in previous years. Finally, similar to the development of the Base4d, an adjustment (i.e., 1.056) was made to account for the difference between HPMS and travel demand model VMT estimates.

The on-road emissions for the other Texas counties, excluding the 11-county HG & BPA nonattainment areas, were developed using county-wide 2007 VMT estimates for each of eight HPMS roadway types obtained from TxDOT. MOBILE5b was used to generate 2007 emission factors assuming the Texas clean gasoline rule (i.e., a 6.7 RVP), the lower average age vehicle distribution, and the federal Tier II/low sulfur standards.

As a part of the attainment modeling for the 8-county HG and 3-county BPA nonattainment areas, TNRCC developed 2007 on-road mobile source emissions. Similar to the DFWRTM area, the HG and BPA 2007 on-road emissions were developed using a travel demand model coupled with the MOBILE5a emissions factor model. Modeling to estimate the future 2007 emissions was actually conducted by the Texas Transportation Institute (TTI) using roadway network and demographic information provided by the Houston-Galveston Area Council of Governments and TxDOT. Further, the emission factors were generated assuming NLEV and the Tier 2/Low Sulfur. These on-road emissions were developed for a four days period of Wednesday through Saturday, for which Wednesday and Thursday constituted a week-day type, Friday was a specific day type and so was Saturday. Thus there were three files for the 2007 on-road emissions for the HG and BPA area. TNRCC used the week-day file for July 1st and 2nd , and the Friday file for July 3rd.

For the other states, the 2007 on-road emissions were estimated by applying an adjustment factor to their Base4d emissions. The adjustment factor was determined by averaging the ratio of the 2007 on-road to the Base4d on-road emissions for all Texas counties.

The following table (Table 5) summarizes the future 2007 base emissions (i.e., 2007b) and compares them with the episodic base emissions, Base4d, for the 4-county DFW nonattainment area.

Table 5
Summary of 2007b & Comparison with Base4d Modeling Emissions
4-County DFW Nonattainment Area

Source Category	**NOx Base4d**	**Emissions 2007b**	**% change**	**VOC Base4d**	**Emissions 2007b**	**% change**
Points	99.4	77.0	-22.5	29.0	28.8	-0.0
Area/Non-Road	156.3	159.0	+1.7	293.8	301.3	+2.6
On-Road	314.5	211.6	-32.7	234.7	135.5	-42.3

Total	570	448	-21.4	558	466	-16.5

d. Future 2007 Emissions Inventory Progression

As mentioned above, in concert with the progression of the episodic modeling emission inventories from Base4d to Base6a, there were a series of future 2007 base modeling emission inventories. For the most part, the progression in the 2007 modeling emissions was due to changes in the episodic emissions, which have already been discussed. However, there were a few changes that only affected the 2007 emission estimates.

Based upon comments from EPA/6 staff, the assumptions regarding point source growth in the various portions of Texas were revised. This basically addressed the issue of banked emissions applicable to NEGFs. In addition, TNRCC removed the SB-766 NOx reductions, and instead included the Agreed orders for Texas Eastman and ALCOA. For EGFs there was a change to the 1996 to 1998 emissions level upon which the 50% NOx reduction as per SB-7 and TNRCC's Rule would apply. The future 2007 on-road emissions were revised, incorporating new Tier 2/Low Sulfur factors obtained from EPAs 1999, "Tier2/Sulfur, Draft Regulatory Impact Analysis." The result of these various changes (i.e., 2007k emissions) for the 4-county DFW area are presented in Table 6, which also compares these emissions with Base6a.

Table 6
Comparison of Base6a & 2007k Modeling Emissions
4-County DFW Nonattainment Area

Source	**NOx**	**Emissions**	**%**	**VOC**	**Emissions**	**%**
Category	**Base6a**	**2007k**	**change**	**Base6a**	**2007jk**	**change**
Points	99.4	123.2	+23.9	29.0	30.1	+3.8
Area/Non-Road	123.3	136.5	+10.7	293.4	304.4	+3.7
On-Road	322.4	216.1	-33.0	234.7	135.8	-42.1
Total	545	476	-12.7	557	471	-15.4

As indicated in Table6, in the 4-county nonattainment area, NOx emissions are to be reduced by about 13% and VOCs by about 15% due to the combine effects of growth and impending emissions.

TNRCC modeled a number of control strategies using the 2007k future base including strategy D_{ATT}, which is the attainment strategy. Table 6a summarizes the change in emissions from base 6a to 2007k to strategy D_{ATT}.

Table 6a
Comparison of Base6a, 2007k & D_{ATT} Modeling Emissions (tpd)
4-County DFW Nonattainment Area

Source	**NOx**	**Emissions**		**VOC**	**Emissions**	

Category	Base6a	2007k	D_{ATT}	Base6a	2007jk	D_{ATT}
Points	99.4	123.2	23.4	29.0	30.1	30.1
Area/Non-Road	123.3	136.5	106.6	293.4	304.4	285.0
On-Road	322.4	216.1	164.3	234.7	135.8	107.6
Total	545	476	294	557	471	423

G. Model Performance

As indicated under the section on episode selection, TNRCC selected two episodes for this attainment demonstration modeling. They were the June 19-22, 1995 and July 1-4, 1996 episodes. Although as mentioned above, TNRCC developed a series of episodic base emissions, model performance evaluations for Base6a are addressed. These evaluations consisted of statistical and graphical performance measures, as well as diagnostic and sensitivity analyses. These attributes of performance are to be used in conjunction with one another. Thus, if the statistics are within the suggested ranges, but the graphical and/or diagnostic and sensitivity analyses indicate performance problems, simulation results used for assessing control strategies should be considered with caution.

The model performance evaluation based upon statistical measures consists of comparing the modeled versus monitored ozone “Unpaired Peak Accuracy”, “Normalized Bias”, and “Gross Error” with the suggested limits in the EPA *Guideline*. Typically, these measures are considered first, since an inability to meet the suggested statistical limits, generally means unacceptable performance. Next, the evaluation based upon graphical measures consisting of comparing time series of monitored and modeled ozone and ozone precursor concentrations, and comparing modeled ozone concentration contours with monitored ozone data is conducted.

The time-series plots depict the hour-by-hour comparison of monitored and modeled concentrations at each monitoring site. The qualitative performance criteria for time series plots consist of the models ability to reproduce the monitored peak concentration, the ability of the model to reproduce the diurnal pattern, and the ability of the model to reproduce the timing of the observations. The modeled ozone concentration contours maps are plots of the isopleths of modeled ozone concentrations at a given hour over the modeling domain. The qualitative performance criteria for concentration contour maps consists of the model’s ability to generate concentration plumes that are spatially and temporally consistent with the monitored concentrations. This is done by viewing a set of these maps (e.g. hour-by-hour), which also include the monitored concentrations, to observe the formation of the concentration plumes, their trajectories, and their decay, in relationship to the monitored concentrations.

The model performance evaluation based upon diagnostic and sensitivity analyses consisted of testing the response of modeled ozone to changes in the various model inputs (i.e., meteorology, emission inventory, and initial & boundary conditions) . The evaluation criteria is again qualitative, and consists of direction (i.e., increase or decrease) and magnitude of the ozone response being reasonable and consistent with the conceptual model.

1. The June 19-22, 1995 Episode

The June 19-22, 1995 exceedance episode occurred with very typical meteorology, calm morning conditions (i.e., stagnation). This particular meteorological regime is associated with the largest number of exceedances for the DFW area. For the two primary episode days (i.e., 6/21-22/95), the maximum ozone recorded was 144ppb, which is only slightly higher than the 139ppb design value.

a. Statistical Measures

Table 7 shows the statistical performance of the model for this episode. The statistical parameters are within the EPA suggested limits for both of the primary episode days, as well as the preceding day. The normalized bias statistic indicates that on average for the monitored values greater than 60ppb, the model tended to under predict ozone concentrations. This is most notable for June 21st for which the model also under predicted the maximum monitored ozone. In addition, the comparability of the normalized bias and gross error for the 21st suggests that the ozone concentration was under predicted at the individual stations. However, overall this is acceptable statistical model performance.

Table 7.
Statistical Performance for the June 20-22, 1995 Episode

Episode Date	Normalized Bias > 60ppb (5 - 15%)	Gross Error>60ppb (30 - 35%)	Unpaired Peak Accuracy (15 - 20%)	Simulated Peak Ozone (ppb)	Measured Peak Ozone (ppb)
6/20/95	-8.1	12.8	7.9	128	119
6/21/95	-10.1	12.2	-7.8	133	144
6/22/95	-8.8	12.5	1.9	138	135

b. Graphical Measures

Figures 4 and 5 show time series of the modeled versus monitored hourly ozone concentrations at selected sites in the DFW area for the June 20-22, 1995 episode, respectively. These sites were selected since on one or both of the primary days either the monitored or modeled ozone concentrations were greater than or equal to 125ppb. Figure 4, for June 21st shows the under prediction of ozone at all four monitoring sites as indicated by the statistics. There are notable under predictions of the peak monitored ozone, especially at DANC, the North Dallas site. The diurnal pattern on the 21st seems to be fairly well replicated at these sites. Although at DMAC, the Denton County Airport, the model appears to have much more ozone carried over to the 22nd. At DANC, the model appears to be carrying over too little ozone. In addition at the DANC site, the afternoon decline in the modeled ozone appears to occur about an hour too early. With regard to the timing of the peak monitored versus peak modeled ozone, they were within one hour of one another at each of the selected monitors. On the 22nd (Figure 5,), there were only two monitoring sites which recorded ozone exceedances (i.e, DANC & DCLC). The model slightly under-predicted the maximum monitored ozone at these sites. The diurnal profile appears to be fairly well replicated, again with the exception, that at the DANC site the afternoon decline in the modeled ozone occurs about an hour too early. The timing of the modeled peak at these two selected sites lags the monitored peak by two hours and three hours, respectively. Although these features somewhat detract from the model performance, they are within an acceptable variance when compared to other modeling applications.

Figure 6 shows graphics of the ozone concentration contour plots of the maximum daily modeled ozone for June 21 and 22, 1995. Also shown are the maximum monitored ozone concentrations. As the plots show, the plume of ozone in excess of 125 ppb appears to be well located with regard to the monitoring site measurements on both days. In fact the location of the maximum modeled ozone is quite similar on both days, occurring between the DANC and DCLC sites. On the 21st, the geographic extent of the plume of excess ozone may be a little small, especially to the west where both the Keller (KELR) and the Denton County (DAMC) sites recorded ozone maximums of 125ppb, and the model predicts values less than 110ppb. On the 22nd, the geographic extent of the plume of excess ozone appears to fit the monitored ozone maxima quite well.

Overall, the graphical evaluation indicated suitable performance of the modeling for this episode. Although there appears to be a noticeable under-prediction on the 21st, it is not considered unacceptable.

c. Diagnostic and Sensitivity Analyses

TNRCC conducted a number of diagnostic and sensitivity analyses for this episode. Diagnostic analyses consisted of zeroing the anthropogenic emissions, zeroing the initial and boundary conditions, and boundary tracers. Sensitivity analyses consisted of using EPA default initial and boundary conditions, using regional scale wind fields, and using 75% of the biogenic VOC emissions. These diagnostic and sensitivity analyses were not conducted using the Base6a emissions, but rather were conducted on an earlier version (e.g. base4) of the episodic emissions for this June 1995 episode. Since the changes between the earlier version and base6a are somewhat notable (e.g., biogenics), there is some question as to the usefulness of these analyses in accessing the performance of the episodic modeling using base6a. However, even evaluating the diagnostic and sensitivity analyses based upon the earlier version may be instructive in determining whether the model responses are reasonable and consistent.

As expected for the zero anthropogenic emissions diagnostic for June 21st & 22nd, ozone concentrations are very much lower than monitored. In fact at $\pm$ 30ppb, they are slightly lower than the generally presumed background of 40ppb. The results of zeroing the initial and boundary conditions for these two days indicate there is a somewhat uniform ozone reduction of about 5ppb, being a little more in the geographical area where the plume of excess ozone was predicted by the model. Without the influence of the initial and boundary conditions, ozone concentrations are expected to be lower, but generally they are lower by around 20ppb.

TNRCC also conducted diagnostic tracer analyses on the initial and boundary conditions. The results of the tracer analysis on the initial conditions were somewhat surprising, indicating that 30 to 60 percent of the tracer (i.e., initial conditions) was still present on the 21st and 20 to 30 percent on the 22nd. Thus even at the end of this five day episode, a notable residual from the initial conditions could be influential. As a result of this analysis, TNRCC revised the initial conditions file for this episode, using monitored ozone, nitrogen oxides and carbon monoxide concentration instead of the default values. The results of the tracer analyses for the boundary conditions (i.e., lateral and top) are summarized in Table 8 for both the 21st and 22nd. As indicated in the table, for both the 21st and 22nd the West and Southern tracers suggest a negligible influence. However, the Eastern and Northen boundary tracers do indicate the possibility of some influence, especially the Northern boundary with 20 to 40 percent of the tracer covering the 4-county area by the 22nd. Also of note is the potential influence from the top boundary condition which is up to 20 percent by the 22nd .

Table 8
Boundary Tracer Analyses
4-County DFW Nonattainment Area

Primary Episode Day	TOP Boundary	South Boundary	West Boundary	North Boundary	East Boundary
June 21, 1995	10 - 20%	~0%	~0%	10 - 20%	~10%
June 22, 1995	20+%	< 5%	~0%	20 - 40%	5 - 10%

However, TNRCC did conduct a sensitivity analysis of the boundary conditions, in which background default values were used for all boundaries (i.e., including the top). For this sensitivity, TNRCC also used background default values for the initial conditions, so the comparison of the results are not specific to just the boundary conditions. The background default values were listed previously in Table 2, as the values for the western boundary. The results of this sensitivity analysis are summarized in Table 9, where the statistical performance measures are compared with the modeling results for an earlier base4 and the current base6a. The comparison in Table 9 indicates that the change in the initial and boundary conditions produces an insignificant change to the model performance. This is especially evident in comparison to the change between base4 and base6a, where the negativity of the normalized bias is notably increased. Thus, based upon these comparisons the modeling results appear to have very little sensitivity to changes in the initial and boundary conditions, even though the tracer analyses seem to indicate there was the possibility for larger influences. This result is reasonable and consistent, since conceptually the initial and boundary conditions are not expected to have much influence on ozone in the nonattainment area.

The Core Wind sensitivity analysis involved substituting the regional 16KM X 16KM SAIMM gridded wind field for the DFW area 4KM X 4KM SAIMM gridded wind field. Aside from the difference in the east/west (U) and north/south (V) wind speed components arising from the use of different grid cell sizes, the regional SIAMM winds were developed using spatially-constant surface characteristics, whereas the winds were developed using spatially-varying surface characteristics for the smaller DFW area. Thus the wind speed components for each set of sixteen - 4KM X 4KM grid cells coincident with a 16KM X 16KM grid cell from the regional SIAMM were replaced with the same wind speed components from the 16KM X 16KM grid cell. The results of this sensitivity analysis are also summarized by considering the change in the model's performance statistics and are shown in Table 9. Similar to the initial and boundary conditions sensitivity, the sensitivity to the winds appears to be quite insignificant, again, especially in comparison to the change between base4 and base6a. In the documentation accompanying the SIP, there were some wind field graphics displaying the substituted regional winds and the DFW Core winds. The graphics show very little change in the hourly wind speeds and directions for the two primary episode days of the 21st and 22nd. For example, the mean difference in wind speed for any hour was no more than $\pm$ 0.4m/s, and much less during the morning hours on the two primary days.

The biogenic sensitivity analysis involved reducing the biogenic VOC emissions by 25 percent. Like the previous sensitivity analyses this one used the earlier base4 sets of inputs. A summary of the results of this analysis is presented in Table 9. These summary statistics show a notable change from the base4 and are actually more comparable to the base6a statistics. The base4a biogenic VOC emission for June 21 & 22 were estimated at 294tpd and 324tpd, respectively, for the 4-county DFW nonattainment area. With a 25% biogenic VOC reduction, June 21 & 22 would have been modeled with 220tpd and 243tpd, respectively. The base6a biogenic emissions for these two days were estimated at 160tpd and 171tpd respectively. Thus the biogenic VOC sensitivity analysis was not as large as the difference between the base4a and base6a. However, even with the 25% biogenic VOC reduction, a notable influence on ozone concentrations was seen. This result is reasonable and consistent, since conceptually the biogenic emissions are expected to have a rather large influence on ozone concentrations.

Table 9
Summary of Sensitivity Analyses, June 1995 Episode

Sensitivity	**NB>60**	**GE>60**
Analyses	**6/21 : 6/22**	**6/21 : 6/22**
Base6a	**-10.1 : -8.8**	12.2 : 12.5
Base4	**-3.0 : -2.6**	10.5 : 10.4
IC & BC's	-1.9 : +1.3	10.2 : 10.6
Core Winds	-1.9 : -2.6	11.3 : 10.5
Biogenics	-10.1 : -9.9	13.0 : 12.8

Overall, the diagnostic and sensitivity analyses indicate changes to the ozone concentrations which are conceptually reasonable and consistent. Thus, even though these analyses were conducted using an earlier version of the episodic modeling emissions, the results seem adequate and supportive of the models performance.

2. The July 1-3, 1996 Episode

The July 1-3, 1996 exceedance episode occurred with very typical meteorology, southerly morning wind conditions on the first two days. This particular meteorological regime is associated with the second largest number of ozone exceedances days for the DFW area. However, for July 3rd, the only 1-hour exccedance day for the episode, the morning winds were out of the west-north-west. The maximum ozone recorded for the July 3rd, primary episode day, was 144 ppb, which is only slightly higher than the 139ppb design value.

a. Statistical Measures

Table 10 shows the statistical performance of the model for this episode. The statistical parameters are within the EPA suggested limits for the primary episode day, as well as the two preceding days. The normalized bias statistic indicates that on average for the monitored values greater than 60ppb, the model tended to under predict ozone concentrations. Although, the normalized bias on the 3rd is quite small. Considering the normalized bias with the gross error for the 3rd suggests that the ozone concentration was under predicted only slightly more often than over predicted at the individual stations. Overall the statistical model performance for the July 3rd primary episode day is acceptable.

Table 10.
Statistical Performance for the July 1-3, 1996 Episode

Episode Date	Normalized Bias > 60ppb (5 - 15%)	Gross Error>60ppb (30 - 35%)	Unpaired Peak Accuracy (15 - 20%)	Simulated Peak Ozone (ppb)	Measured Peak Ozone (ppb)
7/1/96	-14.9	17.0	-3.6	108	112
7/2/96	-10.8	16.1	0.3	114	114
7/3/96	-3.4	15.0	10.5	159	144

b. Graphical Measures

Figures 7a, 7b, and 7c show the time series of modeled versus monitored hourly ozone concentrations at selected sites in the DFW area for the July 1-3, 1996 episode. These sites were selected since on the primary day either the monitored or modeled ozone concentrations were greater than or equal to 125ppb. Figure 14, for July 3rd shows the somewhat off-setting over and under prediction of ozone at the three monitoring sites selected for consideration. This is fairly consistent with the normalized bias and gross error statistics for the 3rd. There are notable over predictions of the peak monitored ozone at both the Meachem (FWMC) and Keller (KELC), approximately by 25ppb and 20 ppb, respectively. Conversely, there is a notable under prediction of the peak monitored ozone at the Redbird (TX44) by approximately 20 ppb. On the 3rd, only two monitoring sites (i.e., FWMC & TX44) recorded ozone exceedances. The TX44 site recorded the 144 ppb episode maximum and FWMC recorded 127 ppb.

The diurnal pattern on the 3rd is only well replicated at KELC, although it is generally under predicted. At the other two sites there are notably missing features in the modeled diurnal pattern. For example, at the FWMC site the monitored values indicate an ozone depression mid-afternoon and a rapid decline in ozone after 1800 hours CST. The modeled values do not show either of these features. Similarly, at the TX44 site, the modeled values do not replicate the rapid decline in ozone after 1600 hours CST that was monitored. However, except for this feature, the modeled diurnal pattern is comparable, although generally under predicted.

With regard to the timing of the peak monitored versus peak modeled ozone, at each of the three sites the peaks were within two hours of one another. In each case the model peaked earlier than the monitor. However, the period of time between the ozone peak at TX44 and the peaks at either FWMC or KELC was the same for both the model and the monitors (i.e., 2 hours).

Figure 8 shows the ozone concentration contour plot of the maximum daily modeled ozone for July 3, 1996. Also shown are the maximum monitored ozone concentrations. As the plot shows the plume of ozone in excess of 125 ppb appears to be displayed slightly to the north and substantially more to the west. The maximum ozone concentrations at FWMC and KELC were both notably over predicted. This displacement of the plume of ozone in excess of 125 ppb is also suggested by noting that the maximum modeled ozone concentration (159ppb) is located about 15 Km from FWMC and KELC, and about 30 Km for TX44 which had the maximum monitored ozone (144ppb).

Although there appears to be a noticeable over prediction and temporal shift at both the FWMC and KELC sites, and an under prediction at the TX44 site, this may be due to the displacement of the plume of ozone. In that case, this episode is still suitable, since the amount of ozone produced is correct. Thus even though, the graphical evaluation indicates that this episode is not replicated as well as the June 1995 episode, the graphical performance is considered acceptable.

c. Diagnostic and Sensitivity Analyses

Similar to the June 1995 episode, TNRCC conducted the same diagnostic and sensitivity analyses for this episode. Diagnostic analyses consisted of zeroing the anthropogenic emissions, zeroing the initial and boundary conditions, and boundary tracers. Sensitivity analyses consisted of using EPA default initial and boundary conditions, using regional scale wind fields, and using 75% of the biogenic VOC emissions. These diagnostic and sensitivity analyses were not conducted using the Base6a emissions, but rather were conducted on an earlier version (e.g. base4) of the episodic emissions for this June 1995 episode. Since the changes between the earlier version and base6a are somewhat notable (e.g., biogenics), there is some question as to the usefulness of these analyses in accessing the performance of the episodic modeling using base6a. However, even evaluating the diagnostic and sensitivity analyses based upon the earlier version may be instructive in determining whether the model responses are reasonable and consistent.

As expected for the zero anthropogenic emissions diagnostic for July 3rd, ozone concentrations are very much lower than monitored. In fact at about 35ppb, they are only slightly lower than the generally presumed background of 40ppb. The results of zeroing the initial and boundary conditions for the 3rd indicate there is a somewhat uniform ozone reduction of about 10ppb in the geographical area where the plume of excess ozone was predicted by the model. Without the influence of the initial and boundary conditions, ozone concentrations are expected to be lower, but generally they are lower by around 20ppb. So this would indicate less influence from the initial and boundary conditions and more influence from the local sources.

TNRCC also conducted diagnostic tracer analyses on the initial and boundary conditions for the July 1996 episode. Similar to the results for the June 1995 episode, the tracer analysis of the initial conditions was somewhat surprising, indicating that about 60 to 70 percent of the tracer (i.e., initial conditions) was still present on the afternoon of July 3rd. Thus, like the June 1995 episode, TNRCC revised the initial conditions file for this episode, using monitored ozone, nitrogen oxides and carbon monoxide concentration instead of the default values. In contrast to the June 1995 episode, the north, east and west tracer analyses suggest a negligible influence, whereas, the southern tracer shows a potential of about 20% by the afternoon of the 3rd. Also of note is the potential influence from the top boundary condition which is up to 20 percent by the 3rd.

As mentioned, TNRCC conducted the same sensitivity analyses for the July 1996 episode as for the June 1995 episode. Table 11 summarizes the results of the sensitivity analyses for July 3rd, the primary day for this episode, using the change in the performance statistics as a gage of the sensitivity. As the results in the table indicate, the initial and boundary conditions produce an insignificant change to the model performance. This is especially evident in comparison to the change between base4 and base6a, where the normalized bias is notably decreased. Thus, based upon these comparisons the modeling results appear to have very little sensitivity to changes in the initial and boundary conditions, even though the tracer analyses seem to indicate there was the possibility for larger influences. In contrast, both the core winds and biogenic sensitivities show notable changes in the performance statistics.

Table 11
Summary of Sensitivity Analyses, July 1996 Episode

Sensitivity	**NB>60**	**GE>60**
Analyses	**7/3/96**	**7/3/96**
Base6a	**-3.4**	15.0
Base4	**12.3**	20.8
IC & BC's	16.6	23.1
Core Winds	23.4	32.4
Biogenics	2.0	16.1

In the documentation accompanying the SIP, there were some wind field graphics displaying the substituted regional winds and the DFW Core winds. The graphics showed a very noticeable difference between the regional and the DFW Core winds, especially over the 4-county nonattainment area. The difference is most apparent in the wind direction, which differed by up to 30 degrees. Although, there were notable wind speed differences, especially in the specific 4-county nonattainment area, where the regional wind speeds were larger (i.e., up to 0.7 m/s). Therefore , this sensitivity analysis probably provides a difference that is in the range of variability that can be expected for winds. However, as Table 11 shows, the performance statistics were severely degraded using the regional winds.

Similar to the biogenic sensitivity for the June 1995 episode, the 25% reduction in VOC produced a notable change from the base4 that is actually more comparable to the base6a statistics. The base4a biogenic VOC emission for July 3rd were estimated at 453tpd for the 4-county DFW nonattainment area. With a 25% biogenic VOC reduction, July 3rd would have been modeled with 340tpd. The base6a biogenic emissions for the 3rd were estimated at 258tpd. Thus the biogenic VOC sensitivity analysis was not as large as the difference between the base4a and base6a. However, even with the 25% biogenic VOC reduction, a notable influence on ozone concentrations was seen. This result is reasonable and consistent, since conceptually the biogenic emissions are expected to have a rather large influence on ozone concentrations.

Overall, the diagnostic and sensitivity analyses indicate changes to the ozone concentrations which are conceptually reasonable and consistent. Thus, even though these analyses were conducted using an earlier version of the episodic modeling emissions, the results seem adequate and supportive of the models performance.

H. Transport from The Houston-Galveston Nonattainment Area

TNRCC submitted evidence of transport from the Houston/Galveston (HG) nonattainment area to support an extension of the attainment date for the DFW area to 2007. DFW currently has a nonattainment area classification of Serious, and thus has a statutory attainment date of 1999. The 1999 ozone design value was 137 ppb.

EPA's guidance on extending attainment dates due to transport is set forth in the July 1998 document entitled, "Guidance on Extension of Attainment Dates for Downwind Transport Areas." In the memorandum from Richard Wilson, then Acting Assistant Administrator for EPAs Office of Air and Radiation, accompanying the extension date policy, it indicates that the policy is to address nonattainment areas that are down wind of other areas that have interfered with the downwind areas' ability to demonstrate attainment by dates prescribed in the 1990 FCAAA. Further, the memo indicates that the attainment date extension will be approved, if certain criteria are met. Additionally, within the 1998 guidance, EPA says that it will consider extending the attainment date for an area that:

(1) has been identified as a downwind area affected by transport from either an upwind area in the same State with a later attainment date or an upwind area in another State that significantly contributes to downwind nonattainment. (By "affected by transport" EPA means an area whose air quality is affected by transport from an up wind area to a degree that affects the area's ability to attain.);
(2) has submitted an approvable attainment demonstration with any necessary, adopted local measures and with an attainment date that shows it will attain the 1-hour standard no later than the date that the reductions are expected from upwind areas under the final NOx SIP call and/or the statutory attainment date for upwind nonattainment areas, i.e., assuming the boundary conditions reflecting those upwind reductions;
(3) has adopted all applicable local measures required under the area's current classification and any additional measures necessary to demonstrate attainment, assuming the reductions occur as required in the upwind areas. (To meet section

182(c)(2)(B), serious areas would only need to achieve progress requirements until their original attainment date of November 15, 1999);
(4) has provided that it will implement all adopted measures as expeditiously as practicable, but no later than the date by which the upwind reductions needed for attainment will be achieved."

To address the first provision, "that the transport from HG affects DFW's ability to attain the NAAQS", TNRCC presented several technical analyses. TNRCCs first technical analysis used "Zero-Out" modeling, a procedure applied in the OTAG modeling for evaluating "significant contribution", as an indication of the effects of HG emissions on DFW. The elimination of the HG emissions (i.e., "Zero-Out" modeling) shows there was a transport of approximately 2 to 10ppb from the HG nonattainment area to the southern and eastern portions of the DFW nonattainment area for the two modeled episodes, June 1995 and July 1996. Generally, in OTAG, a "Zero-out" modeling analysis of the upwind area's emissions which resulted in a 2ppb or greater impact to the downwind area was considered significant. Thus, at least on these two episodes, emissions from HG contributed significantly to ozone concentrations in the southern and eastern portions of the DFW nonattainment area. However, this does not suffice to conclude that the contribution from HG emissions affects DFW's ability to attain.

TNRCC included another technical analysis addressing the frequency of transport. This analysis presented back trajectories for 160 DFW 1-hour and/or 8-hour exceedance days from the five year period 1994 through 1998. These back trajectories showed that 21out of the 160 trajectories traced back to the Upper Texas Gulf Coast. During this five year period, there were 45 1-hour exceedance days (i.e., ~ 28% of the 160) in the DFW nonattainment area. If it is assumed that the same proportion holds for the 21 trajectories which trace back to the Upper Texas Gulf Coast, then about 6 out of the 45 1-hour exceedance days have associated transport that may be traced back to the Upper Texas Gulf Coast. Averaged over the 5-year period, this would indicate that just over one exceedance per year out of an average of nine for DFW during this period may be associated with transport from the Upper Texas Gulf Coast. This means that potentially in a three year period just over three exccedance days (i.e., a violation) may be associated with transport from the Upper Texas Gulf Coast.

Taken together these two technical analyses indicate the magnitude and frequency of the affect of HG emissions on the DFW area and that transported pollution may well have affected DFW's ability to attain by the current attainment date (i.e., 1999).

TNRCC has submitted a SIP for the DFW nonattainment area that appears to be approvable. The SIP includes the adoption of the local control measures used in the attainment demonstration. The attainment demonstration assumes a 2007 attainment date and a level of emission reductions in HG that takes into account many of the control measures (e.g., vehicle tier 2 and low sulfur fuel) expected to be part of the control strategy needed to achieve attainment for that nonattainment area. In addition, all control measures required for a serious classification have been adopted for the DFW nonattainment area. Thus both the second and third criteria listed above have been met.

Although the attainment demonstration modeling uses 2007 as an implicit implementation date, TNRCCs SIP indicates that the implementation of the various control measures constituting the D_{ATT} will be made as expeditiously as practicable. For example, all state and local control measures are scheduled for implementation no later than 2005.

J. Future Case Modeling

The future case modeling was conducted using the projected 2007 EI as previously described. The non-point source, projected 2007 EI was forecasted from the June 1995 and July 1996 episodic EIs using various assumptions regarding emission growth and controls. The point source, projected 2007 EI was developed from the maximum daily emissions for 1997, or the maximum 30-day average for the 1996 to 1998 period for EGFs. The boundary conditions used in the future case modeling were derived from the regional modeling (using the OTAG 2007 EI) similar to the boundary conditions used in the episodic modeling. The same meteorological files were used for the future case as used in the episodic modeling. Also as indicated in the previous section describing the development of the 2007 emissions, there were a series of future 2007 base modeling emission inventories. The future 2007 control strategy modeling (i.e., D_{ATT}) is based upon the future 2007 base emission inventory derived from Base6a. Table 12 summarizes the modeling emissions and maximum modeled ozone concentrations.

Table 12
Summary of Modeling Emissions and Maximum Modeled Ozone Concentrations
4-County DFW Nonattainment Area

Scenario Designation	Parameter	6/21	6/22	7/3
	NOx	524 tpd	526 tpd	572 tpd
Base6a	VOC	779 tpd	814 tpd	815 tpd
	O3	133 ppb	138 ppb	159 ppb
	NOx			502 tpd
Future Base	VOC			728 tpd
	O3	121 ppb	126 ppb	144 ppb
	NOx			321 tpd
Control strategy, D_{ATT}	VOC			681 tpd
	O3	110 ppb	113 ppb	132 ppb

As shown in Table 12, the July 3rd primary day is the controlling day, and even with the proposed control strategy, the future predicted daily maximum ozone concentration is still in excess of the NAAQS (i.e., 124ppb). Figure 9 shows ozone contour plots for the controlling day of July 3rd, depicting the geographical coverage of ozone for base6a and the proposed control strategy D_{ATT}.

K. Weight of Evidence Applications

EPA's 1996 guidance, "Guidance on Use of Modeled Results to Demonstrate attainment of the Ozone NAAQS", allows for the weight of evidence (WOE) analyses to supplement attainment modeling, when the control strategy modeling leaves a few grid cells (e.g., 2 to 3) with ozone concentrations in excess of the NAAQS. The intent of this guidance was to be mindful of the ozone standard, which allows for the occurrence of some ozone exceedances. Thus, even though the control strategy modeling may forecast some areas to still be slightly above the NAAQS, this does not necessarily mean, that with the implementation of the control strategy, monitored attainment will not be achieved. In such situations, WOE analyses can be included, as part of the overall attainment demonstration, which provide compelling technical implications that monitored attainment will be achieved.

Since the modeling results for the D_{ATT} control strategy forecast some areas to still be slightly above the NAAQS (i.e., 132 pppb), TNRCC elected to supplement the control strategy modeling with WOE analyses for the overall attainment demonstration. Of the WOE analyses presented, EPA/6 finds the following to be most pertinent: 1) Additional Ozone Metrics, 2) Future Design Value, and trend analyses.

Table 13 lists some pertinent ozone metrics for the base6a, the future 2007 base, and the proposed control strategy, D_{ATT}, for July 3rd, the controlling day.

Table 13
Modeled Ozone Metrics for the July 3rd, Control Day

Modeling	Ozone	Metrics	
Scenarios	**Peak Ozone**	**Area w/O3>124**	**Area-Hours w/O3>124**
Base6a	159 ppb	2464 KM^2	7232 KM^2-hr
Future Base	144 ppb	1404 KM^2	3696 KM^2-hr
Control strategy, D_{ATT}	132 ppb	272 KM^2	416 KM^2-hr

Each of these metrics indicates a substantial decrease from the base6a to the control strategy. For example, the geographical area where modeling predicted the 1-hour ozone concentration to be greater than the NAAQS (i.e., 124 ppb) is reduced by about 90% from the Base6a to the D_{ATT} controlled case.

The Future Design Value (DV_f) WOE analysis is patterned after the methodology for demonstrating attainment of the proposed eight-hour ozone standard. Chiefly, the monitored design value applicable to the episode modeled (e.g., 1996), is multiplied by a relative reduction factor (RRF), derived from the episode and control strategy modeling results, to estimate the future design value (DV_f). The analysis considers only those days for which monitoring or episodic modeling indicate an exceedance of the ozone NAAQS somewhere in the relevant portion of the modeling domain. In conducting this analysis TNRCC used a data exclusion provision to eliminate modeling results where ozone concentrations were relatively low, which they felt would bias the results. If the base case modeling results in the vicinity of a monitoring site meet one of the following conditions then the RRF was not used for that station for that day:

1. DV_c>= 125 ppb and the modeled maximum ozone < 100pppb for a site; or
2. DV_c<125 ppb and the modeled maximum ozone < (DV_c-20) ppb for a site.

Although the future design value (DV_f) WOE analysis is not a substitute for the one-hour attainment demonstration, it can provide an indication of what the DV_f may likely be, given full implementation of the control strategy. Table 14 summarizes the DV_f WOE analysis.

Table 14
Summary of the DV_f WOE Analysis.

Site Code	'95-'97 DV_c	1995 6/20	RRF 6/21	6/22	1996 7/02	RRF 7/04	Mean RRF	DV_f
DANC	134 ppb	0.84	0.85	0.84	0.89	0.81	0.846	113 ppb
DCLC	129 ppb	0.83	0.85	0.84	0.94	0.81	0.854	110 ppb
DHIC	121 ppb	0.87	0.86	0.89	0.81	0.87	0.860	104 ppb
DTMA	139 ppb	0.81	0.81	0.84	0.82	N/A	0.820	114 ppb
FRIC	132 ppb	0.83	0.83	0.83	0.95	0.81	0.850	112 ppb
FWMC	133 ppb	0.85	0.85	0.85	0.85	N/A	0.850	113 ppb
KELC	131 ppb	0.85	0.83	0.85	0.85	N/A	0.845	111 ppb
TX44	134 ppb	0.86	0.84	0.87	0.81	N/A	0.845	113 ppb

notes: DV_c is the episode applicable design value.
DV_f is the estimated future design value.
RRF is the ratio of the D_{ATT} to Base6a in the vicinity of the sites.
N/A (non-applicable) refers to TNRCC's data exclusion provision

Table 14 indicates that the DV_f at all stations is expected to be less than the NAAQS.

TNRCC presented trend analyses for 6-9 am TMNOC (Total Non-Methane Organic Carbon), monthly averaged morning NOx, and the ozone design value. Figure 10 displays trend lines for each of these parameters. The TMNOC trend line shows a statistically significant decrease. As presumed by TNRCC this reduction is probably the result of the Federal Motor Vehicle Control Program (FMVCP) and the change in fuels to lower vapor pressure gasolines. Trends analysis of NOx was presented for a number of sites, which indicated that some may have had a minor decrease, some a minor increase and some show no appreciable change at all. TNRCC's conclusion,to which EPA/6 concurs, was that compared to the TNMOC change over time, the NOX has not experienced any meaningful change. The NOx trend graphic shown in Figure 10 is based upon a comparable data set to the TNMOC trend for the DHIC site.

The trend in the ozone design value for the DFW area is shown in the final graphic in Figure 10. Although this trend shows a decrease, over the past few years the ozone design value appears to have remained fairly constant.

Considering the trends in TNMOC, NOx and ozone together, TNRCC concluded that the higher TNMOC and ozone in the early 1980s and the lower TNMOC and ozone in recent years was indicative of a reduction in the ozone design value due to reductions in VOC. In addition, TNRCC concluded that the rather constant or possibly increasing NOx trend has hampered further ozone reductions and thus NOx needs to be reduced to achieve further reductions in the ozone design value. Since the modeling strongly suggests that ozone is most sensitive to NOx reductions and since the trends of NOx and ozone have been mostly constant over the past 10 years, it seems reasonable to expect the ozone design value to be reduced by reducing NOx emissions.

L. Summary

The model's performance in predicting ozone was sufficient to meet EPA's performance criteria. In addition, the demonstration of transport from the HG nonattainment area, appears to meet the policy aspect and supports an extention of the attainment date to 2007. Further, the attainment demonstration, composed of the control strategy modeling and WOE analyses is considered acceptable.